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Maine Department of Transportation

Transportation Research Division

Technical Report 99-8

Experimental Use of Geogrids as an Alternative to Gravel Placement

Interim Report - Second Year, August 2002

Transportation Research Division

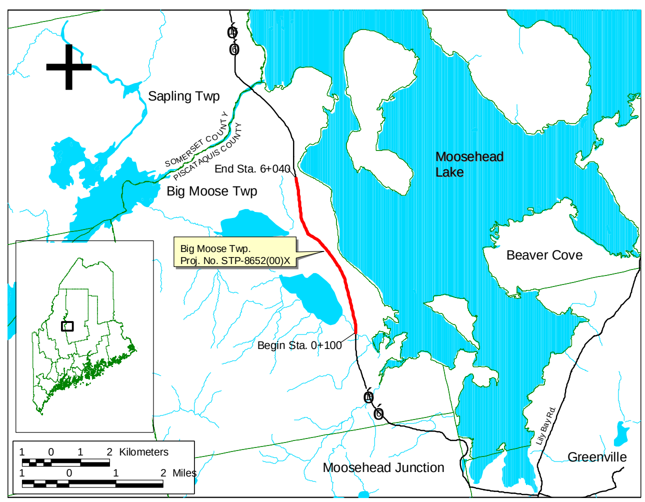
Experimental Use of Geogrids as an Alternative to Gravel Placement

Introduction

With the ongoing demand for improved infrastructure, the Maine Department of Transportation (MDOT) continues to identify and evaluate new and innovative construction methods and materials. The Department's Capital Highway Improvement Program (CHIP) attempts to reduce construction costs by utilizing existing roadway base and pavement materials. In the fall of 1998, MDOT began construction of a project that incorporated this philosophy and an experimental feature of geogrids to minimize the need for additional base gravel materials.

Project Location/Description

This project is located on Route(s) #6-15 in Big Moose Township (formerly Big Squaw Township), Piscataquis County. This 5.94-kilometer section of roadway was originally identified to receive a standard 16 mm maintenance mulch overlay. After further review and several discussions concerning the significant distortion (crown) of the existing roadway and the high volume of heavy truck traffic, it was determined that this section was an excellent candidate for the CHIP process.



The experimental feature of this project consists of 11 sections of varying length encompassing the entire project length. The primary focus of this research was to determine if placement of a geogrid product could minimize the need for additional base gravel materials.

As this research evolved, it became apparent that not only could MDOT evaluate the effectiveness of geogrids, but also conduct an analysis on each of the construction procedures utilized within this project.

MDOT's Geotechnical group played a significant role in selecting the geogrid product used in the research portion of this project and in establishing the overall research strategy. The geogrid product is Biaxial Geogrid BX1200 (SS-2), manufactured by The Tensar Corporation of Morrow, Georgia.

Table I presents the section locations, treatment and final average gravel and pavement depths.

TABLE I. Section Details

Section Number	Location (m)	Treatment	Final Gravel Depth (mm)	Final Pavement Depth (mm)
1	0+100 - 0+220	Undercut	650	110
2	0+220 - 0+600	Geogrid	685	115
3	0+600 - 0+700	Control	750	115
4	0+700 - 2+770	Reclaim	685	115
5	2+770 - 3+270	Geogrid	700	95
6	3+270 - 3+390	Control	640	110
7	3+390 - 3+520	Geogrid	540	115
8	3+520 - 5+120	Reclaim	590	110
9	5+120 - 5+320	Geogrid	680	120
10	5+320 - 5+400	Undercut	420	165
11	5+400 - 6+040	Reclaim	650	115

Construction Procedures

Preliminary Falling Weight Deflectometer (FWD) data was collected in June 1998, for design considerations. This evaluation included FWD testing at 150-meter intervals and 25 pavement, base and subgrade explorations using power augers randomly located along the project. The data was then combined with traffic information and analyzed using DARWin 3.01 software to develop necessary gravel and pavement thickness for the project's construction. A 15-year design life was used to develop each layer thickness.

Construction of the 5.94-kilometer project began in mid-September 1998. This late season start did not allow sufficient time to complete the entire project. However, all of the pavement reclamation and base material work was completed, and the 65 mm Superpave binder coarse was applied and left exposed for the winter season of 1998-1999.

With the exception of the two undercut sections, pavement was reclaimed the entire project length using a Wirtgen Pavement Reclaimer. This reclamation process consisted of full depth reclaiming of the existing pavement layer, plus approximately 25 mm of the existing gravel base. Pavement depths varied from 60 to 125 mm.

During the grinding process, it was noted that the reclaimed material was of poor quality and became muddied with rainfall. Quality of this material was improved by applying 75 to 100 millimeters of gravel to the existing pavement before grinding.

In late January 1999, maintenance personnel identified two areas of pavement failure within the project and a decision was made to restrict heavy loads from traveling along the constructed section. This "posting" was implemented using the MDOT's standard posting procedure which limits gross vehicle weights to 23,000 pounds except when air temperatures fall below 32 degrees Fahrenheit and water is not present at roadway cracks. This posting minimized any additional failures and overall, the project performed adequately.

In early spring, 1999, additional FWD testing was performed on the binder coarse to determine if the total pavement depth of 105 millimeters would sufficiently support future traffic weight and volume. Several areas of minor deficiency were identified and treated with additional pavement at the time of wearing surface placement.

Final pavement depths for the project consisted of 65 millimeters of Superpave 19 mm binder course, and Superpave 12.5 mm surface course at depths ranging from 30 to 100 millimeters.

A summary of each construction procedure follows:

Undercut Sections

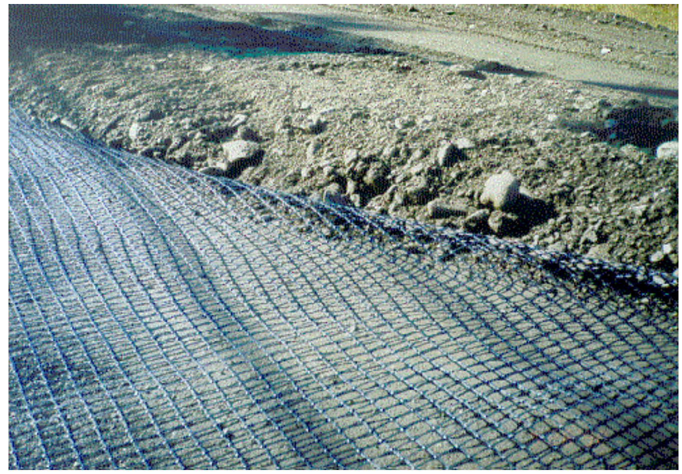
In the two undercut sections (1 and 10), existing roadway materials were excavated at varying depths between 300 and 600 millimeters. As anticipated, ledge was encountered in several areas of section #1. Gravel and pavement materials were reintroduced at a depth of between 760 and 800 millimeters for section #1, and a depth of between 550 and 585 millimeters for section #10. As stated above, FWD testing in the spring of 1999 identified deficient loading capacities in several areas including section #10. To correct this deficiency, an additional 50 mm of wearing surface was placed.

Geogrid Sections

In the four Geogrid sections (2, 5, 7 and 9), existing pavement material and 25 mm of gravel base material were ground in-place and leveled to grade using a grader to eliminate excessive crown. Two rolls of geogrid product, each measuring 4 meters in width and approximately 50 meters in length were then placed on top of the reclaimed material at full roadway width. Construction of each Geogrid section was completed using this 50-meter interval to minimize traffic interruptions.

The geogrid product were overlapped and attached at the center and ends using “tie connectors”. These ties were rated at 75 pounds tensile strength. After initial application, it was determined that a single tie did not supply adequate strength and two connectors were used at each tie location.

Both lanes of traffic were stopped during this process, until a single lane width layer of gravel of varying depth (300 mm minimum) could be placed over the longitudinal seam at the center of the roadway. Once single lane traffic flow was reestablished, the left and right side of the geogrid was covered to a total width of 7.3 meters. Some “pushing” or “waving” of the geogrid product was observed during gravel application. This movement was not considered critical but it did create concern with respect to ease of application.



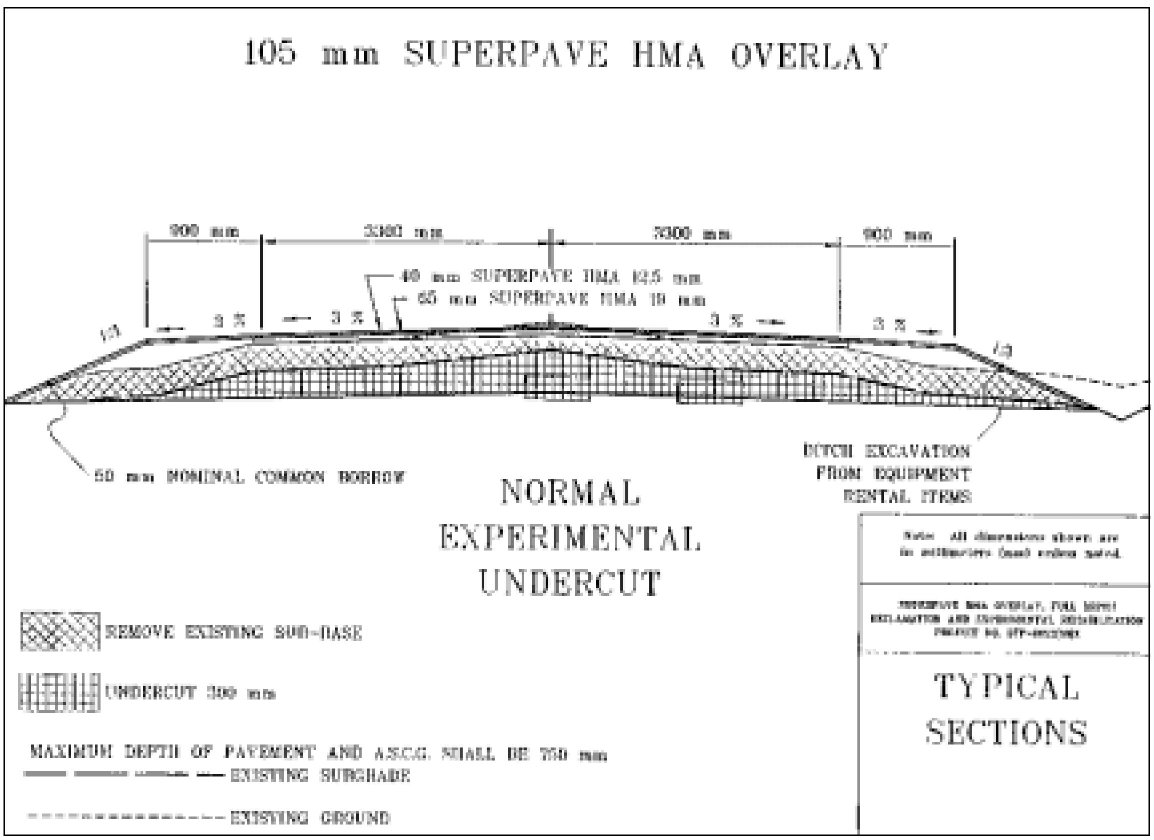
Control Sections

The two Control sections (3 and 6) were constructed in the same manner as the Geogrid sections, with the exclusion of the geogrid product and its associated procedures.

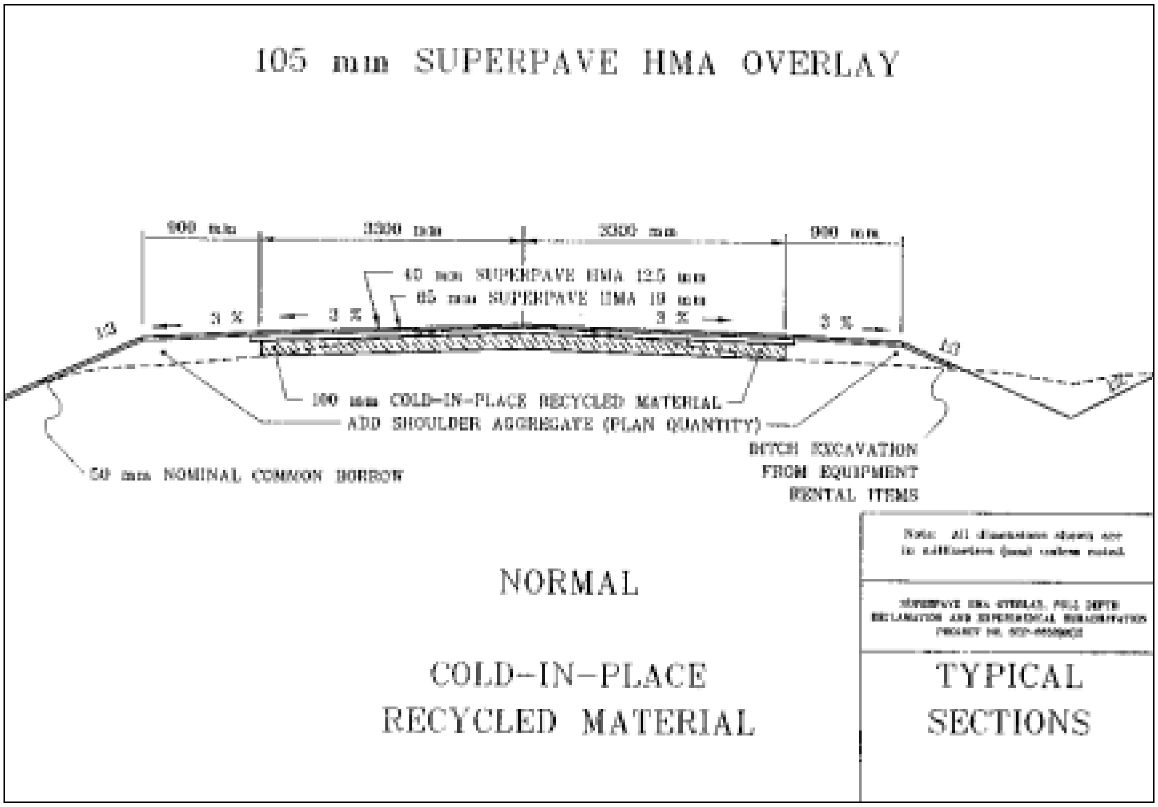
Reclaim Sections

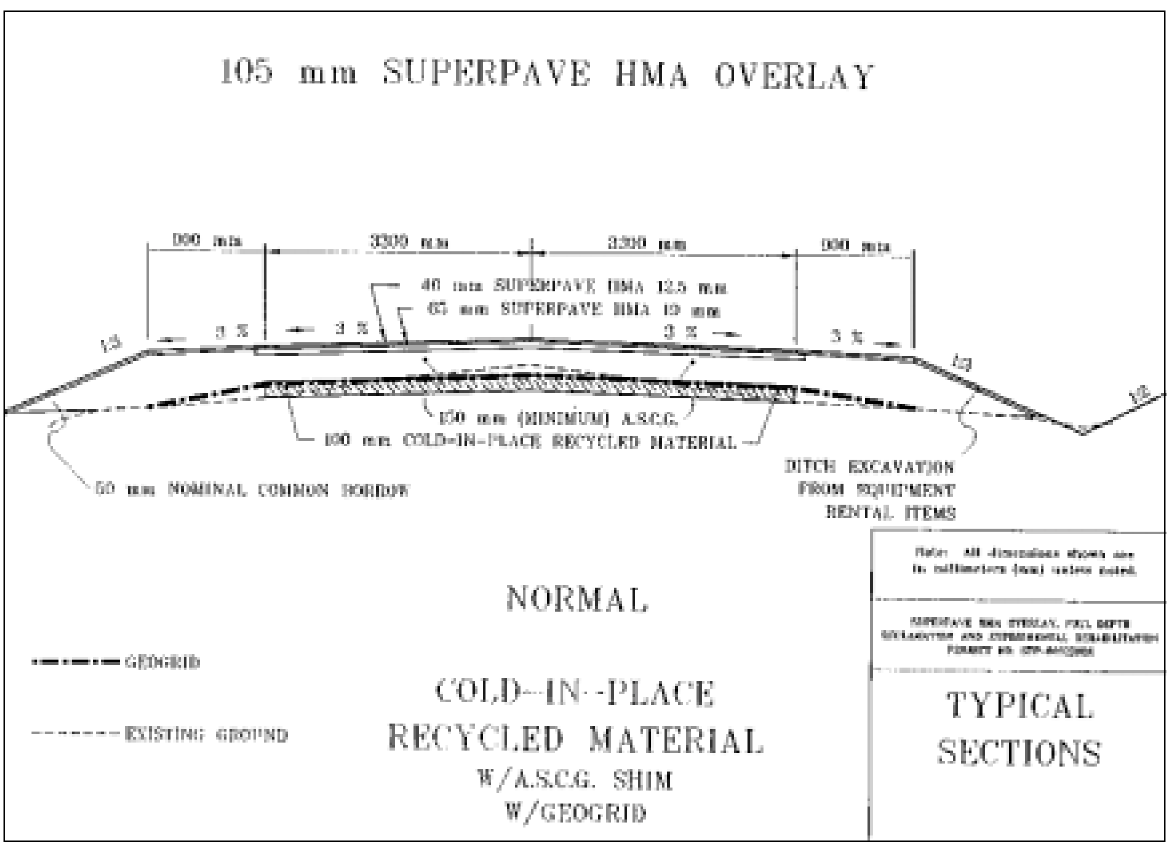
Construction of the three Reclaimed sections (4, 8 and 11) included the reclamation of the existing pavement layer and 25 mm of the existing gravel base material. Gravel was added at depths of 75 to 100 millimeters where necessary as stated earlier. This material was then leveled to grade and pavement layers applied.

TYPICAL CROSS SECTION DETAILS



TYPICAL CROSS SECTION DETAILS (continued)





Project Evaluation

Visual Inspection

Unfortunately, a visual inspection of the experimental sections was not conducted in the year 2001. A visual evaluation will be included in the Third Interim Report.

Falling Weight Deflectometer

On August 2001, FWD testing was completed in each of the 11 sections. Four drops, each generating approximately 9000 pounds of force, were used at each test location. Deflection measurements were recorded and this data was then analyzed using DARWin 3.01 software. Overall Subgrade Modulus, Pavement Modulus and Effective Existing Structural Numbers were then developed for each section. These values were computed using a minimum of 10 test points per section.

Table II compares the Subgrade Modulus, Pavement Modulus, and Effective Existing Structural Number values from FWD data obtained in September 1999, September 2000, and August 2001.

With the exception of section 1, which has ledge in several areas, all Subgrade Modulus values have increased from year 2000 readings. Tests to determine “statistically significant” increases were not completed but will be done in future analysis. The summer of 2001 was uncommonly dry and this may have contributed to the increased values.

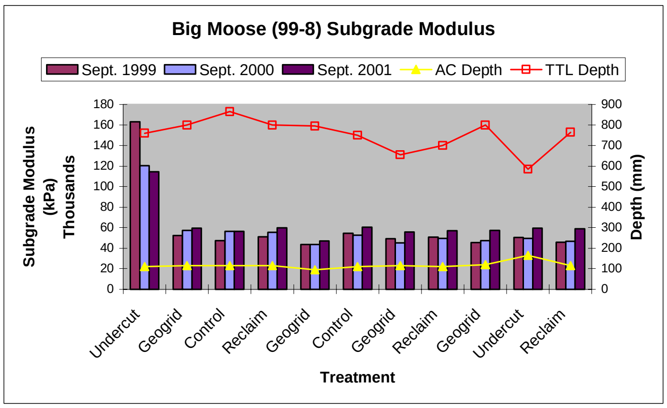
Pavement Modulus values in sections 1, 2, 3, and 7 have decreased from year 2000 values. Sections 9 thru 11 have increased significantly by as much as 28 percent.

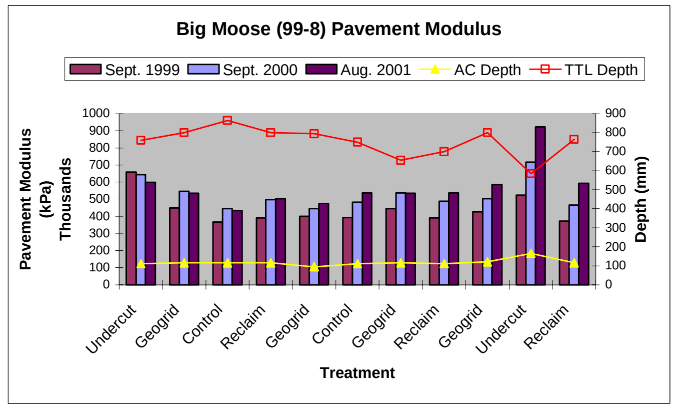
Effective Existing Structural Number values have decreased slightly from 2000 readings in sections 1, 2, and 3 and remained the same for section 7. Values in sections 10 and 11 have increased by 11 and 12 numbers respectively. Once again, dry weather may have contributed to the increased Pavement Modulus and Effective Existing Structural Numbers.

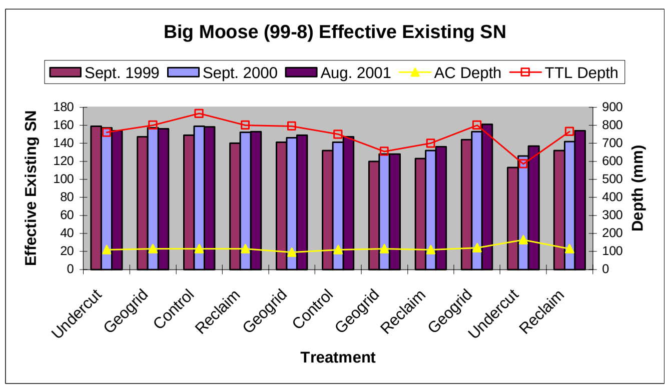
To date, the Effective Existing Structural Number of Geogrid sections 2, 5, and 9 appear to be reacting similarly to its surrounding sections. Geogrid section 7 has the same Structural Number as in year 2000 while the surrounding sections have increased. This could be attributable to the reduced amount of subbase material used in this section.

TABLE II. FWD Analysis Sept. 1999 to Aug. 2001

Section Number	Treatment	Treatment Layer Depths: Average AC Depth (mm)	Treatment Layer Depths: Average Total Depth (mm)	September, 1999 Construction Complete: Subgrade Modulus (kPa)	September, 1999 Construction Complete: Pavement Modulus (kPa)	September, 1999 Construction Complete: Effective Existing SN	September, 2000 1st Year Evaluation: Subgrade Modulus (kPa)	September, 2000 1st Year Evaluation: Pavement Modulus (kPa)	September, 2000 1st Year Evaluation: Effective Existing SN	August, 2001 2nd Year Evaluation: Subgrade Modulus (kPa)	August, 2001 2nd Year Evaluation: Pavement Modulus (kPa)	August, 2001 2nd Year Evaluation: Effective Existing SN
1	Undercut	110	760	163064	658346	159	120349	642962	157	114494	599042	154
2	Geogrid	115	800	52273	448042	147	57420	546419	157	59507	535732	156
3	Control	115	865	47305	366081	149	56368	445187	159	56374	433826	158
4	Reclaim	115	800	51199	389413	140	55552	497300	152	59781	503876	153
5	Geogrid	95	795	43596	399803	141	43600	446052	146	47115	475294	149
6	Control	110	750	54539	392367	132	52606	483008	141	60520	538154	147
7	Geogrid	115	655	49332	445664	120	45341	538150	128	55826	535459	128
8	Reclaim	110	700	50822	390489	123	49742	488167	132	56886	536243	136
9	Geogrid	120	800	45498	426052	144	47208	502440	153	57323	586073	161
10	Undercut	165	585	50564	524946	113	49382	717667	126	59455	922357	137
11	Reclaim	115	765	45781	371220	132	46646	466068	142	58890	593924	154







ARAN International Ride Index

Smoothness data was collected using the ARAN test vehicle. This is an ASTM Class II profile-measuring device that is capable of accurately measuring roadway smoothness.

Table III contains ranges of IRI values and a verbal description of each.

TABLE III. IRI Range and Description

IRI (Meters/Kilometer)	IRI (Inches/Mile)	Verbal Description
1.02 - 1.57	65 - 99	Comfortable ride at 105/65 kph/mph. No noticeable potholes, distortions, or rutting. High quality pavement.
1.58 - 3.15	100 - 199	Comfortable ride at 88/55 kph/mph. Moderately perceptible movements induced by occasional patches, distortions, or rutting.
3.16 - 4.73	200 - 299	Comfortable ride at 72/45 kph/mph. Noticeable movements and swaying induced by frequent patches and occasional potholes. Some distortion and rutting.
Greater than 4.73	Greater than 299	Frequent abrupt movements induced by many patches, distortions, potholes, and rutting. Ride quality greatly diminished.

Table IV contains International Ride Index (IRI) values of each section from 1999 to 2001.

Control section 3 has the smoothest ride at 1.19 m/km (75.4 in/mi). Although this is the smoothest ride, it is the third highest increase at 12 percent from last year.

Geogrid section 7 has the roughest ride at 1.71 m/km (108.3 in/mi). Although this is the roughest Section, the increase is only 5 percent higher than last year.

Undercut section 1 has the second highest profile at 1.64 m/km (103.9 in/mi) and the largest increase of 41 percent from last year.

The remaining sections have a range of values from 1.21 to 1.35 m/km (76.7 to 85.5 in/mi).

With the exception of Geogrid section 7, all Geogrid and Reclaim sections have stable values in the range of -2 to 3 percent compared to last year.

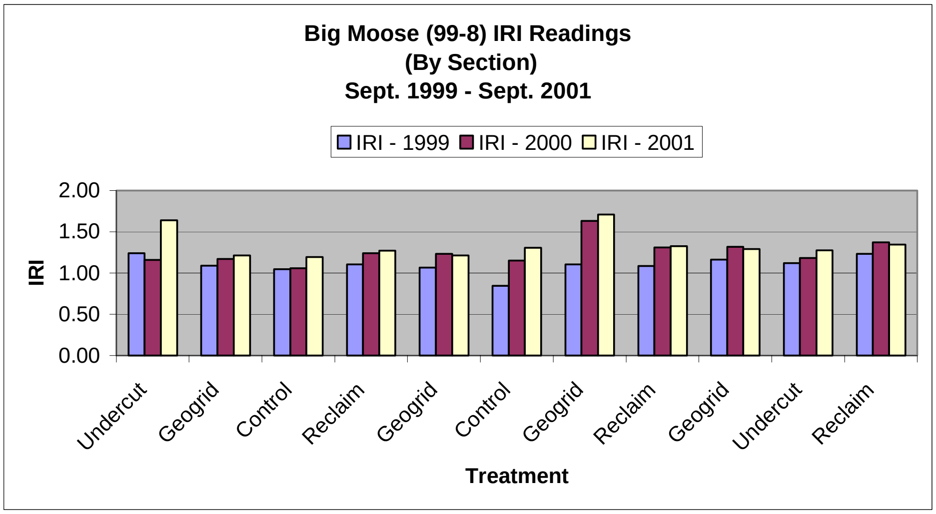
The two Undercut and Control sections have the largest increase in values ranging from 8 to 41 percent.

All sections are within the smooth rating of 0 -3 m/km (0 - 190 in/mi).

Future tests will determine if geogrid material improves long-term smoothness of the road.

TABLE IV. IRI Values Sept. 1999 - Sept. 2001

Section Number	Treatment	Average IRI (meters/kilometer)		
		Sept. 1999	Sept. 2000	Sept. 2001
1	Undercut	1.24	1.16	1.64
2	Geogrid	1.09	1.17	1.21
3	Control	1.05	1.06	1.19
4	Reclaim	1.10	1.24	1.27
5	Geogrid	1.07	1.23	1.21
6	Control	0.85	1.15	1.30
7	Geogrid	1.10	1.63	1.71
8	Reclaim	1.08	1.31	1.33
9	Geogrid	1.16	1.32	1.29
10	Undercut	1.12	1.18	1.28
11	Reclaim	1.23	1.37	1.35



ARAN Rut Depth

Rut depth measurements were collected using the ARAN test vehicle. Table V illustrates Average Rut Depths for each section from September 1999 to September 2001.

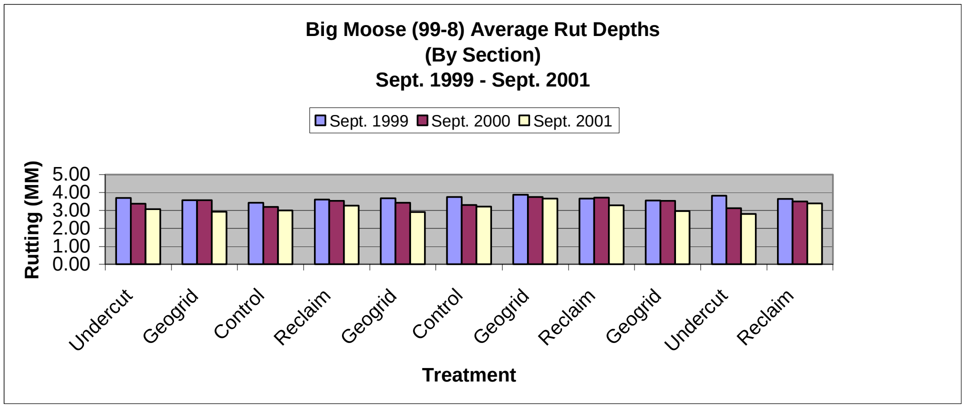
After two years of traffic, the project, as a whole, is supporting traffic well with very little rutting. Ruts range in depth from 2.81 mm (0.11 in) to 3.67 mm (0.14 in). All sections are showing an 18 to 2 percent decrease from last years evaluation. This equates too less than 1 mm in depth. The project has a low volume of traffic, with an AADT of 1650, allowing logging trucks to ride the center of the road. This may be depressing the centerline and quarter point of the roadway, which could decrease rut depths in each wheel path.

Undercut section 10 has the least amount of rutting at 2.81 mm (0.11 in) and Geogrid section 7 has the deepest rutting at 3.67 mm (0.14 in).

With such a small amount of rutting, it is difficult to determine if one section is outperforming another.

TABLE V. Rut Depth Values Sept. 1999 - Sept. 2001

Section Number	Treatment	Average Rut Depth (millimeters)		
		Sept. 1999	Sept. 2000	Sept. 2001
1	Undercut	3.70	3.38	3.08
2	Geogrid	3.57	3.58	2.93
3	Control	3.44	3.20	3.00
4	Reclaim	3.61	3.54	3.27
5	Geogrid	3.68	3.43	2.92
6	Control	3.75	3.30	3.21
7	Geogrid	3.88	3.75	3.67
8	Reclaim	3.66	3.71	3.28
9	Geogrid	3.56	3.53	2.98
10	Undercut	3.83	3.13	2.81
11	Reclaim	3.64	3.49	3.40



Rolling Dipstick

As detailed in the Construction report for this project, a Rolling Dipstick was utilized in an effort to monitor vertical movement of eight cross culverts along the project. Data was collected in April 2001 and again in August 2001 as part of the annual evaluation process. Comparisons of IRI readings were made for fall 1999, 2000, and 2001 seasons to monitor movement of the culverts on a yearly basis. Results are summarized in Table VI.

The greatest profile change occurred in Reclaim sections at culvert number 1 and 8. Culvert 1 had a 48 percent increase in IRI and culvert 8 had a 28 percent increase.

Culvert number 2 and 6 in Geogrid sections had an increase in IRI of 27 and 18 percent respectively. Culvert 3, located in a Geogrid section, had a slight increase in IRI of 2 percent. Geogrid culvert number 4 has the highest IRI value at 3.16 m/k and a slight increase in IRI of 2 percent.

Culvert number 7 in a Control section and number 5 in a Reclaim section had a decrease in IRI values of -5 and -10 percent respectively. IRI values for culvert 7 have decreased each year whereas culvert 5 has decreased only in the 2000/2001 season, but remains relatively uniform for the three-year period.

Once again, IRI readings displayed minimal change from 2000 to 2001 with the exception of culvert number 4 located in a Geogrid section at station 3+432. The end of the culvert at this location appears to have lifted near the edge of the northbound travel lane and continues to hold this position.

TABLE VI. Rolling Dipstick Culvert Profiles

Culvert Location	Treatment	Average IRI (meters/kilometer)		
		Sept. 1999	Sept. 2000	Sept. 2001
2+314	Reclaim	0.70	0.87	1.29
2+957	Geogrid	0.86	0.87	1.10
3+110	Geogrid	1.15	1.30	1.33
3+432	Geogrid	2.00	3.09	3.16
4+221	Reclaim	0.71	0.79	0.71
5+162	Geogrid	0.74	0.92	1.09
5+349	Control	1.12	1.06	1.01
5+459	Reclaim	1.08	1.06	1.35

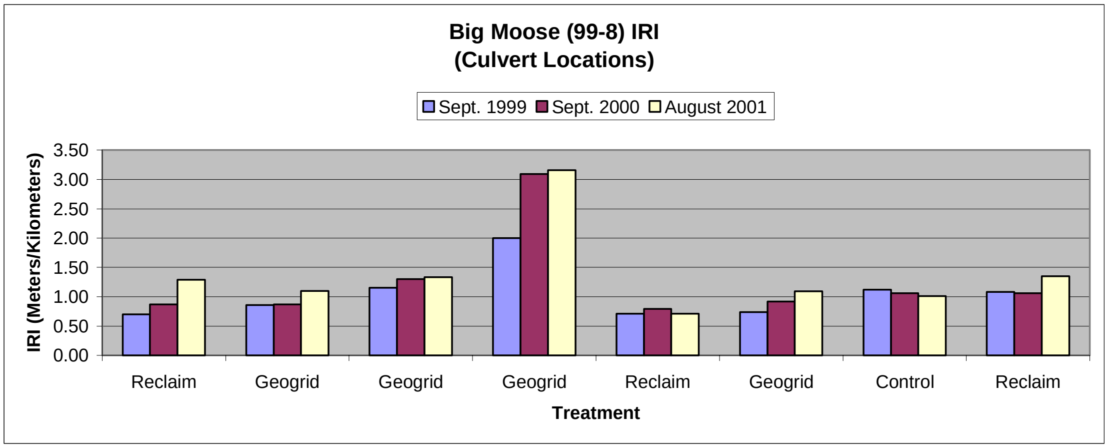


Table VII contains IRI values of culvert areas comparing spring and fall profiles within the same year.

The 2001 data indicated a reduction in movement as compared to the spring/fall of 2000.

The greatest movement is in Reclaim culvert 1 and Geogrid culvert 4 with a reduction in IRI of 0.79 and 0.74 m/km respectively.

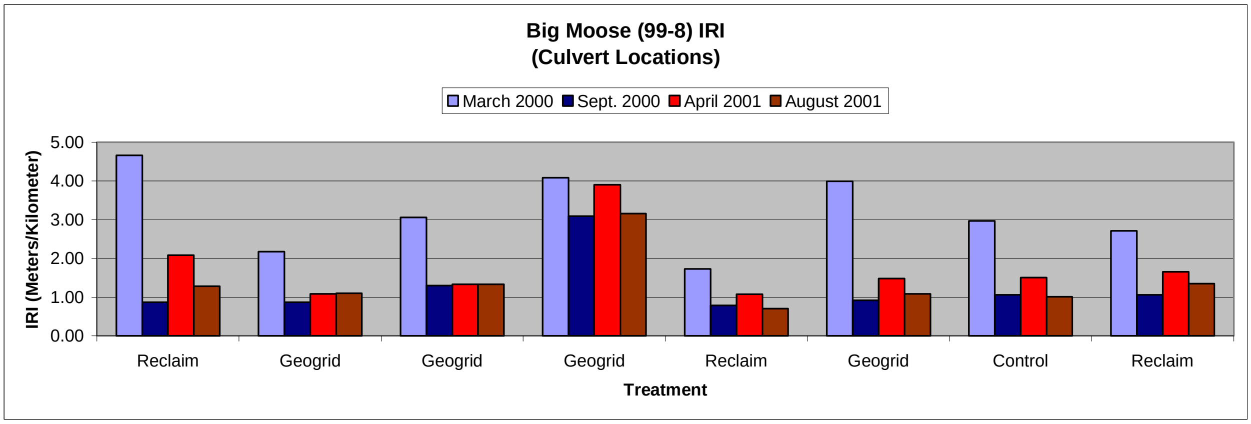
Control culvert number 7 had an IRI difference of 0.50 m/km.

Culvert number 5 and 8 in Reclaim sections and Geogrid culvert number 6 have a difference in spring/fall IRI values of 0.37, 0.31, and 0.39 m/km respectively.

Geogrid culvert number 2 and 3 are very stable with slight movement.

TABLE VII. Rolling Dipstick Culvert Profiles (Spring / Fall)

Culvert Location	Treatment	Average IRI (meters/kilometer)			
		March 2000	Sept. 2000	April 2001	August 2001
2+314	Reclaim	4.66	0.87	2.08	1.29
2+957	Geogrid	2.18	0.87	1.09	1.10
3+110	Geogrid	3.06	1.30	1.33	1.33
3+432	Geogrid	4.08	3.09	3.90	3.16
4+221	Reclaim	1.73	0.79	1.08	0.71
5+162	Geogrid	3.99	0.92	1.48	1.09
5+349	Control	2.97	1.06	1.51	1.01
5+459	Reclaim	2.71	1.06	1.66	1.35



Summary

Data collected in 2001 has not indicated obvious advantages in either section. Future evaluations should indicate which treatment is better suited for this type of roadway.

The next field evaluation is scheduled for fall of 2002. FWD, ride, rut, and culvert data as well as visual analysis data will be collected and presented in the Third Year Interim Report

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Other Available Documents:
Construction Report, December 1999
Interim Report - First Year, February 2001

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